METHODS OF SAMPLING AND TESTING
MT 422-04
METHOD OF TEST FOR SURFACE SMOOTHNESS AND PROFILE

1 Scope:

1.1 This method covers the testing of the finished flexible pavement surface for surface smoothness and surface profile. The surface smoothness is expressed in International Roughness Index (IRI) units of inches/mile or meters/kilometer. The surface profile is generated using Profile Index (PI) measurements and variations from this profile are expressed in inches/25 feet or millimeters/7.62 meters. This method is not intended to be used with rigid pavements or gravel surfacing.

2 Referenced Documents:

2.1 MDR 4080/4097 Mobile Data Recorder Operation Manual, International Cybernetics Corporation. All of the procedures for the actual operation of the road profilers are detailed in this user's manual.

3 Apparatus:

3.1 Class I laser road profiler – The manufacturer mounts the road profiling system on an automobile and performs the initial calibration of the system.

4 Calibration:

4.1 The manufacturer performs the initial calibration of the entire profiling system immediately after mounting the system on the vehicle.

4.2 Distance calibration (Conduct the distance calibration according to the MDR 4080/4097 Mobile Data Recorder Operation Manual from International Cybernetics Corporation.)

4.2.1 At screen 4-1, which is the Main Menu, highlight **Calibration** and hit enter. A pull-down menu will appear with **View** as the first choice. Highlight **View** and hit enter. This will bring up a screen that displays all the system configuration and calibration parameters from the sensor, accelerometer, and distance sections. Check these to make sure they are correct and then make a print out of the display. Do this by holding the **Shift** key and hitting the **Print Scrn** key with the printer on. Save this print out with the project test results as verification of the profiler's calibration prior to acceptance testing.

4.2.2 At the Main Menu, highlight **Calibration** and hit **Enter**. A pull-down menu will appear. Arrow down to **Distance** and hit **Enter**. The Distance window allows you to enter a Distance Calibration Factor (DCF) directly or establish a DCF by performing a calibration procedure. Each profiler must have a distance calibration performed at least once a week or after 2,000 miles of tire wear. The baseline distance for this calibration must be 5,280 feet (1,609 meters) or greater.

NOTE - The longer the pre-measured course used to calibrate the MDR system, the greater the accuracy of the data gathered.

4.2.3 The Distance menu has **DCF** and **Go** options. The DCF option includes the actual DCF entered in the MDR presently. This is a maximum of six (6) numbers followed by a letter. The number displayed is dependent on several factors that are established during the calibration procedure. The menu will also display one of the following three letters.

C Indicates that the entry was entered by completing the calibration process.

4 Calibration: (continued)

E Indicates that a DCF number has been entered into the system.

U Indicates that no entry of calibration has been performed by the operator.

4.2.4 Highlight the **DCF** option and hit **Enter** if entering an established DCF number. If a DCF number has not been established or a weekly calibration has not been performed, a distance calibration must be performed.

4.2.5 To perform a distance calibration procedure, position the test vehicle at the start position of the baseline course and select the **Go** option on the Distance menu and hit **Enter**.

4.2.6 This will activate a screen that will ask for the calibration distance of the baseline course. Enter the length of the course and hit **Enter**. This will bring up the Perform Distance Calibration Screen.

4.2.7 This distance calibration window allows the operator to store and average up to ten different DCF's. This is to reduce error in the DCF. To start a calibration procedure, press **F3**. This will cause another screen to appear in the distance calibration window that displays a pulse count giving the total number of pulses received from the distance sensor during the calibration test.

4.2.8 Hit **Enter** to start the calibration process and drive the length of the course.

4.2.9 When the test vehicle reaches the end of the measured course, press **BkSp** to stop the calibration process. If the run was normal and the number valid, it will be stored and displayed by the system. If the operator is not happy with the DCF, he may press the F8 key. This will delete the DCF that is highlighted. The UP and DOWN arrows can be used to highlight a selection for deletion.

4.2.10 If more DCF's are needed, press the F3 key. This makes the system ready for another run over the baseline course.

4.2.11 Repeat steps 4.2.8 and 4.2.9 as many times as necessary. The DCF average is updated constantly and displayed on the top line.

4.2.12 Once an ample number of DCF's have been recorded, use the arrow keys to move the highlighted area to either the (AV) average value or the one particular DCF that you would like to use. Once the desired value has been highlighted, hit the **F2** key to select the chosen value and the system will then display a verification line at the top of the screen.

4.2.13 Press the **Enter** key to store the highlighted DCF as the new system DCF. The system DCF is displayed on the lower left corner on the Distance Calibration screen.

4.2.13.1 If for any reason there was a mistake made that would affect multiple DCF's during calibration, press the **F9** key. Once the **F9** key is depressed, a verification line will appear at the top of the screen. The operator must then press the **Y** key for deletion. This will wipe out all DCF's and reset the distance calibration procedure.

4.2.14 To generate a hard copy of the Distance Calibration screen press the F7 key. A hard copy should be created and saved each time the calibration is performed.

4.2.15 When the calibration procedure is completed and the new DCF is saved, press the **F10** key. This will remove the system from the distance calibration collection mode.

*NOTE - Exiting does not automatically save the DCF average as the new value. The **F2** key should be used to save the new DCF in memory before exiting.*

4 Calibration: (continued)

4.3 Accelerometer calibration (Conduct the accelerometer calibration according to the MDR 4080/4097 Mobile Data Recorder Operation Manual from International Cybernetics Corporation)

4.3.1 The calibration of the accelerometer must be performed prior to beginning testing on each project.

4.3.2 At the **Calibration** menu, arrow down to **Accelerometer** and hit **Enter**.

4.3.3 A pulldown menu appears displaying the various accelerometer calibration parameters. These calibration parameters are:

ACcelerometer(s) = the number of configured accelerometers
ACF = Accelerometer Calibration Factor
FGF = Filter Gain Factor
HPF = Integrator Filter High Pass Frequency

4.3.4 The values displayed on the Accelerometer menu are generated by the MDR system when the Go function is activated, followed by the appropriate command(s). To generate the values select the **ACF** window and press **G** for Go and an accelerometer calibration screen will appear.

4.3.5 This screen displays the accelerometer calibration characteristics. Press **Enter** to start the accelerometer calibration.

4.3.6 Press **Bksp** to stop the calibration after a minimum of 2000 samples.

4.3.7 Press **Y** or **Enter** to accept the ACF and FGF values. Press N when you don't want to accept the values. When amplifier/filter is set for a gain of 2, the ACF values will be 1024 + 20, while the FGF will be between 1.97 and 2.00. If the amplifier/filter is set for a gain of 1, the ACF values will be 512 + 10 and the FGF will be between 1.01 and 99.

NOTE - The acceleration calibration should be done every day after the system has been warmed up for at least 15 minutes. The vehicle should be on a level section of pavement and anyone who is going to be involved with testing should be in his or her proper place in the vehicle during this calibration.

4.3.8 The values established by performing the sensor calibration procedure and displayed on this menu should be recorded for future reference.

4.4 Accuracy confirmation of laser height sensors (Check the accuracy of the laser height sensors according to section 6.3.3.9 of the MDR 4080/4097 Mobile Data Recorder Operation Manual from International Cybernetics Corporation).

4.4.1 The calibration check on the height sensors must be performed prior to beginning testing on each project.

4.4.2 The check must be performed on a level surface such as a garage floor.

4.4.3 Turn the system on and let it warm up for at least 10 minutes.

4.4.4 At the **Calibration** menu, arrow down to **Sensors** and hit **Enter**.

4.4.5 At the **Sensors** menu press **G** for Go. The Perform Sensor Calibration screen will appear.

4.4.6 Press **Enter** to start the sensor calibration.

4. Calibration: (continued)

4.4.7 Press **BkSp** to stop the calibration after a minimum of 1000 samples.

4.4.8 Press **N** or **Enter** since you do not want to accept the SCF(s).

4.4.8.1 The average height value displayed is in feet and depicts the distance from the laser camera standoff to the pavement/floor. A typical number will be 0.328 feet for a 200 mm laser and 0.210 feet for a 128 mm laser.

4.4.8.1.1 When changing a laser, installing, or reinstalling a laser, this should be checked first.

4.4.8.1.2 The value should be within + 0.03 feet of the required value on a straight floor with the operator(s) in the vehicle. The laser mounting plate should be adjusted to make the value within + 0.01 feet considering the levelness of the floor.

4.4.8.1.3 A calibration must be performed and the SCF values saved after the adjustments and check-out are accomplished.

4.4.8.2 After you have taken a base reading, place an object (i.e. metal calibration bar) of a known thickness under the laser camera.

4.4.8.3 The values on the screen should adjust exactly the thickness of the object. If they do not, contact the Pavement Management Section before you proceed.

4.4.8.4 The displayed numbers should be recorded. However, do NOT save the values.

4.5 Laser height sensor calibration (Calibrate the laser height sensors following the procedure outlined in section 6.3.3.10 of the MDR 4080/4097 Mobile Data Recorder Operation Manual from International Cybernetics Corporation).

4.5.1 Calibration of the height sensor system should be done at least once every three months or whenever a sensor is added, changed, or removed from a vehicle.

4.5.2 The check must be performed on a level surface such as a garage floor.

4.5.3 At the **Calibration** menu, arrow down to **Sensors** and hit **Enter**.

4.5.4 A pull down menu will appear.

4.5.4.1 Highlight the **Cal Temp** selection and hit **Enter**.

4.5.4.2 Enter the proper air temperature.

NOTE - This value must be entered prior to a sensor calibration. Do not change the Cal Temp if the sensor calibration factors (SCF) are not to be saved.

4.5.4.3 Arrow down to the **sEnsor config** selection and hit **Enter**.

4.5.4.4 The user can choose the sensor type by selecting the position number and toggling the enter key. The four selections are; None, Acoustic, Selcom 200 and Selcom 128. Check and make sure the correct sensors are shown.

NOTE - If the wrong sensor type is entered, the system will report invalid data. A sensor calibration must be performed after the sensor type is changed.

4. Calibration: (continued)

4.5.4.5 The remaining choices on this pulldown menu are as follows:

SCF - The SCF function is a system generated value. The value is used by the MDR system to mathematically compute the optimum levelness of the ultrasonic transducers mounted on the front bumper of the test vehicle.

Rate - The Rate function indicates the number of DMI pulses counted before a height measurement is sampled. It also indicates the maximum speed that the vehicle may travel without expecting errors due to too fast a sampling rate with ultrasonic sensors during testing. There are two rate categories: Laser & Acoustic. The rates categories enable the mix of lasers and ultrasonic sensors.

Low and High Values - The Low and High values are used to establish height values that the system should report errors in height measurement data from the ultrasonic transducers. This distance is calculated by the MDR system and is displayed for operator information as well as put into the data files. The error count can be monitored in both the calibration mode and the run mode.

Spacing - The Spacing function is used to enter the horizontal distance between the sensors. This allows proper rut depth calculations when five or more sensors are used (Note: MDT will not be using the rut depth functions in the testing for surface smoothness).

4.5.5 To perform the actual sensor calibration, select the **sensors** window and press **G** for Go. The Perform Sensor Calibration screen will appear.

4.5.5.1 This menu displays the number of sensors that are selected in the Run mode Options window. The sensor Calibration characteristics are:

Number of Samples - The number of readings taken by the sensors during the calibration procedure. A minimum of 1000 samples is recommended.

Sensor - The height sensor position number on the test vehicle.

Count - The count in microseconds the sensor required for the last height sample.

Height - The height of the last sample.

Avg. Height - Average height of all samples.

Gate/Zero - Number of hardware errors detected.

Low - Number of sensor readings that are below the Low limit.

High - Number of sensor readings that exceed the High Limit.

Dif - Number of samples where differences in successive samples are greater than 381mm.

Total - Total number of errors detected.

4.5.5.2 Press **Enter** to start the sensor calibration.

4.5.5.3 Press **BkSp** to stop the calibration after a minimum of 1000 samples.

4.5.5.4 Press **Y** only if this was an actual calibration and you want to accept the SCF(s). If it was not an actual calibration hit N or Enter.

4. Calibration: (continued)

NOTE - The values established during the calibration procedure are displayed on this menu. The values are also displayed on several other menus of the MDR system and are discussed to the appropriate depth for that application. It is recommended that the values established and displayed on this menu be recorded for future reference.

4.6 Statewide uniformity confirmation

4.6.1 A five mile calibration site will be set up in each district.

4.6.2 Take IRI measurements on the calibration site once a week or any time a problem is suspected.

4.6.2.1 The overall IRI value recorded on the entire five mile test site should not vary more than + 2 in/mile (0.032 m/km) from the average of the previous five tests conducted on the site.

4.6.2.2 Each of the 0.1 mile (0.3 km) sections should vary from the average of the previous five tests on that section by 10 in/mile (0.16 m/km) or less.

4.6.2.3 If a the calibration test does not pass the requirements of 4.6.2.1 and/or 4.6.2.2, rerun the calibration site making sure all of the proper procedures are followed.

4.6.2.4 A record should be kept of each time the calibration site is tested.

4.6.3 Measure the calibration site in the district, or in Helena, at the same time as one of the Pavement Management profilers and compare the results.

4.6.3.1 The side by side results of the two test runs should meet the same criteria established in 4.6.2.1 and 4.6.2.2.

4.6.3.2 The side by side tests should be conducted at least twice a year.

5 Project Testing:

5.1 Preparation of Surface:

5.1.1 The department will test the roadway only when it is free of moisture and any deleterious material that would not provide accurate test results. The contractor is responsible for all work to prepare the roadway for testing, such as, but not limited to sweeping.

5.1.2 Testing will not be conducted while it is raining or under other weather conditions determined inclement by the Engineering Project Manager.

5.2 Preliminary Project Preparation

5.2.1 Meet with the Engineering Project Manager (EPM) or one of his representatives and identify the Beginning-Of-Project (BOP), End-Of-Project (EOP), and all bridges that are not paved as part of the project. It will be necessary to conduct **two** runs, one for PI, and one for IRI. The order of testing is not important. A traffic cone must be set approx. 500 feet in advance of the begin point of testing and one approx. 500 feet beyond the end point of testing for both PI and IRI tests.

5.2.1.1 PI Test - Place event markers 25 feet (7.6 meters) prior to the BOP transverse paving joint, 25 feet (7.6 meters) after the EOP transverse paving joint. (See drawing, page 12)

5.2.1.2 IRI Test - Place event markers 150 feet (46 meters) after the BOP connection and 150 feet (46 meters) before the EOP connection. Place an orange traffic cone (non reflective) on edge of roadway at all bridge ends.

5. Project Testing: (continued)

5.2.2 Note any areas requiring additional traffic control to ensure a constant testing speed is maintained and work with the EPM to make arrangements for this traffic control.

5.2.3 Establish a beginning stationing and whether or not it is an English or metric project and use the measurement system consistent with the project stationing.

5.3 Profiler Set-up:

5.3.1 Turn on the main power switch for the MDR system.

5.3.2 Type M at the C: prompt and press Enter

5.3.3 As the MD090L program starts it will check for height sensors and accelerometers and attempt to operate them. If the hardware is not running properly or an invalid configuration is detected, the appropriate error message(s) will be displayed.

5.3.4 If everything is running properly the system will now display the Main Menu. This menu consists of the following choices; **Options**, **Parameters**, **Calibration**, **Run**, **File**, and **Quit**. Use the arrow keys to highlight the desired option and press Enter. This will bring up a pull down menu for the desired category.

5.3.4.1 The first menu to select is the **Options** menu. This is where the reference post display is selected. The options for this are feet, miles, meters, or kilometers.

5.3.4.2 Second, open the parameters window and put in the names of both the driver and the operator of the MDR system.

5.3.4.3 The next step is to go through all of the necessary system and sensor calibrations outlined in section “4. Calibration” of this test procedure.

5.3.4.4 Choose **Run** once the required calibration is completed. A fill in the blank menu with the following characteristics will open.

County - A 15 character alphanumeric field

Route - A 10 character alphanumeric field

Direction - N, S, E, W, A, D, F, R. Selects direction as North, South, East, West, Ascend, Descend, Forward, or Reverse and sets Asc/Dsc to + for N A F & E or – for S D R & W. Asc/Dsc can change the + or – as required also.

Beg Ref Point - Beginning point in meters, kilometers, feet, or miles. Entering a whole number implies feet or meters, while a decimal value implies miles or kilometers, as appropriate.

Asc/Dsc Ref Point - Change ref point to ascend or descend in value. Use after direction is selected to change sign.

Lane - A 10 character alphanumeric field.

Options - Allow data collection options to be changed.

Data Directory - File path for storing data files (**d:\(**four digit control number ex. 4582)**\(**lane designation ex. nb)**** (**iri** if collecting iri or **pi** if collecting pi) ex. d:\4582\nb\iri

5. Project Testing: (continued)

1 File Name - A 15 character alphanumeric field. Use **run1** for file name. If more than one run per iri/pi/lane is necessary then name subsequent files run2, run3, etc.

2 Ref - A 15 character alphanumeric field

3 Ref - A 15 character alphanumeric field

Weather - Sets of values describing weather information

NOTE - Some user codes selected in the Options Window will cause the above fields to have their names changed or will have the values in selected fields be used to name the data file. Use as appropriate for your established operations.

5.3.4.5 Enter all of the relevant information that is needed on the final report.

5.3.5 The system is now ready to begin testing. Select **Go** under the **Run** menu and the data collection screen will come up.

5.3.5.1 ***PI test*** - Bring vehicle up to speed and press the **F3** key to start the data collection process at the first cone approximately 500 feet in advance of the new pavement.

5.3.5.1.1 The profiler will automatically actuate an F9 function at the reflective tape that was placed 25 feet before the BOP and will automatically actuate an F8 function at the reflective tape that was placed 25 feet beyond the EOP.

5.3.5.1.2 Press the **F3** key at the cone that was placed approx. 500 feet beyond the test pavement to stop the data collection process.

5.3.5.1.3 The F10 key should be used to exit the data collection and save the data collected into a disk file. The screen will then show the name of the file including the path to which data will be saved.

NOTE - If the ESC key is hit, you will be given the option to save data. If you say "no", the data will be lost completely. This should only be done if the data is not to be saved on disk.

5.3.5.2 ***IRI test*** - Bring vehicle up to speed and press the **F3** key to start the data collection process at the first cone approximately 500 feet in advance of the new pavement.

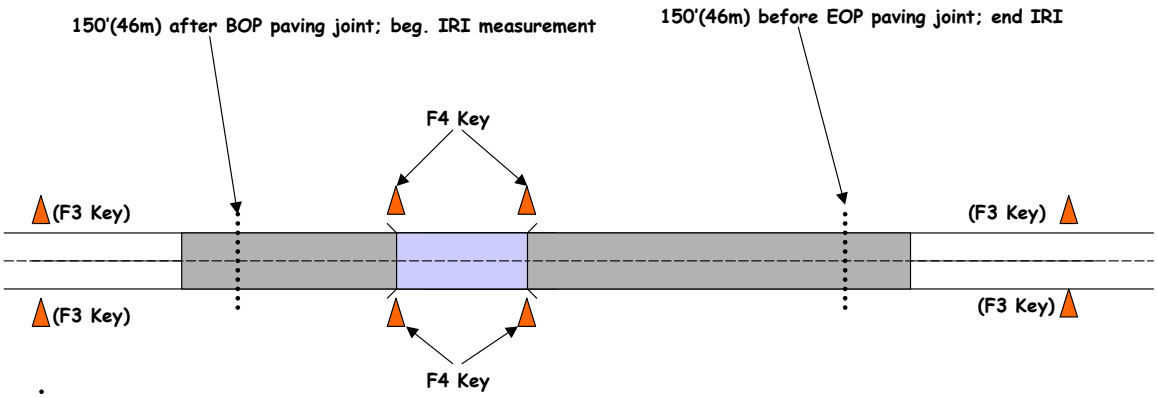
5.3.5.2.1 The profiler will automatically actuate an F9 function at the reflective tape that was placed 150 feet after the BOP joint and will automatically actuate an F8 function at the reflective tape that was placed 150 feet before the EOP joint. The operator will manually actuate an F4 function at cones placed on the bridge ends of all bridges that should be excluded according to the ride specification. The profiler will automatically omit IRI measurement 150 feet ahead and 150 after the F4 location.

5.3.5.2.2 Press the **F3** key at the cone that was placed approx. 500 feet beyond the test pavement to turn the roughness measurement off.

5.3.5.2.3 The F10 key should be used to exit the data collection and save the data collected into a disk file. The screen will then show the name of the file including the path to which data will be saved.

NOTE - If the ESC key is hit, you will be given the option to save data. If you say "no", the data will be lost completely. This should only be done if the data is not to be saved on disk.

IRI Measurement Layout (project)

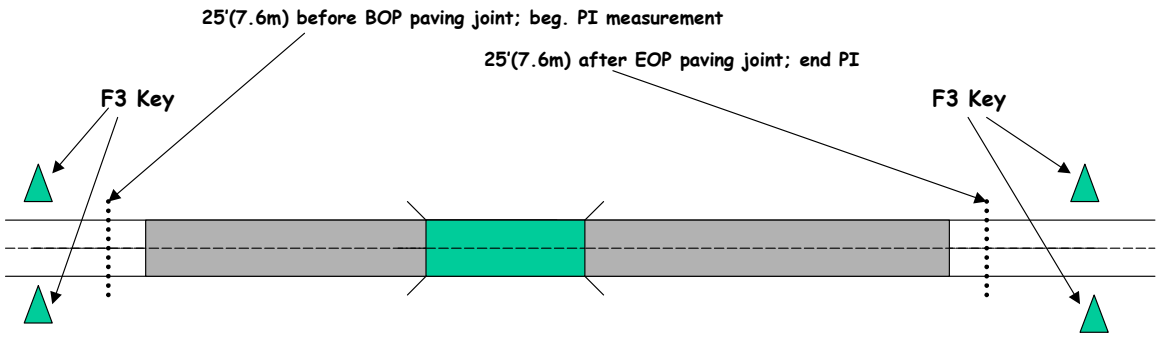


Event Markers (reflective tape on rdwy.) Equipment will automatically actuate F9 then F8 at tape.

Traffic Cones, Set approx 500 feet before and after paving joints and at all bridge ends on bridges that are excluded from ride spec.

Note: The F3 and F4 key are manually actuated by operator

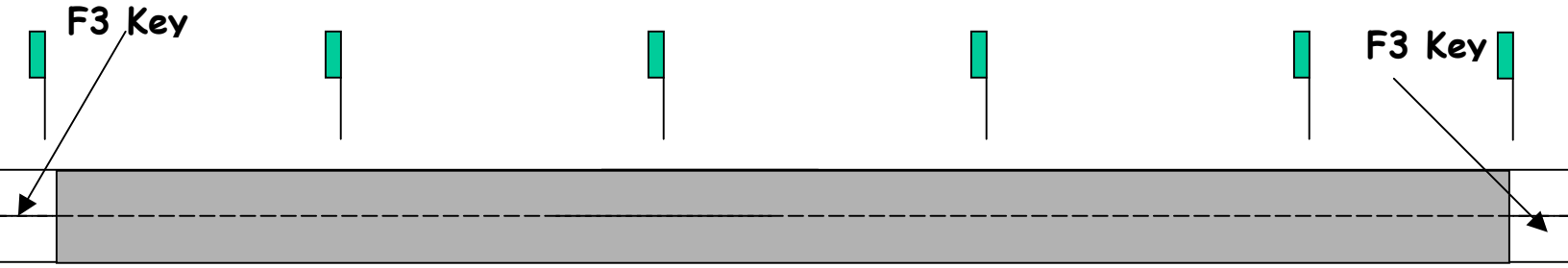
PI Measurement Layout (project)



Event Markers (reflective tape on rdwy.) Equipment will automatically actuate F9 then F8 at tape.

Traffic Cones, placed Approx. 500' before and after paving joint. Manually actuate F3 key here.

Five Mile Calibration Run Layout



Instructions:

1. Make sure vehicle is warmed up and static calibration performed
2. Go to Options screen, select Mile
3. Go to Run screen:
4. In Data Directory, type G:\ (this will default to the zip drive)
5. In Filename, type current date for file name (ex. aprl1400 cannot exceed 8 chars.)
6. Select Go
7. Bring vehicle up to speed and press the F3 key at the first milepost
8. Press the F3 key again at the last milepost
9. Press F10, then esc. Then press enter at filename box
10. Type Q then Y
11. At the C:\> prompt type G: (you will then be in the G: drive, be sure to have a disk in the zip
12. At the G:\> prompt type DIR to check for files
13. Type dist4IRI space filename space 1 then press return (ex. dist4IRI april400 1)